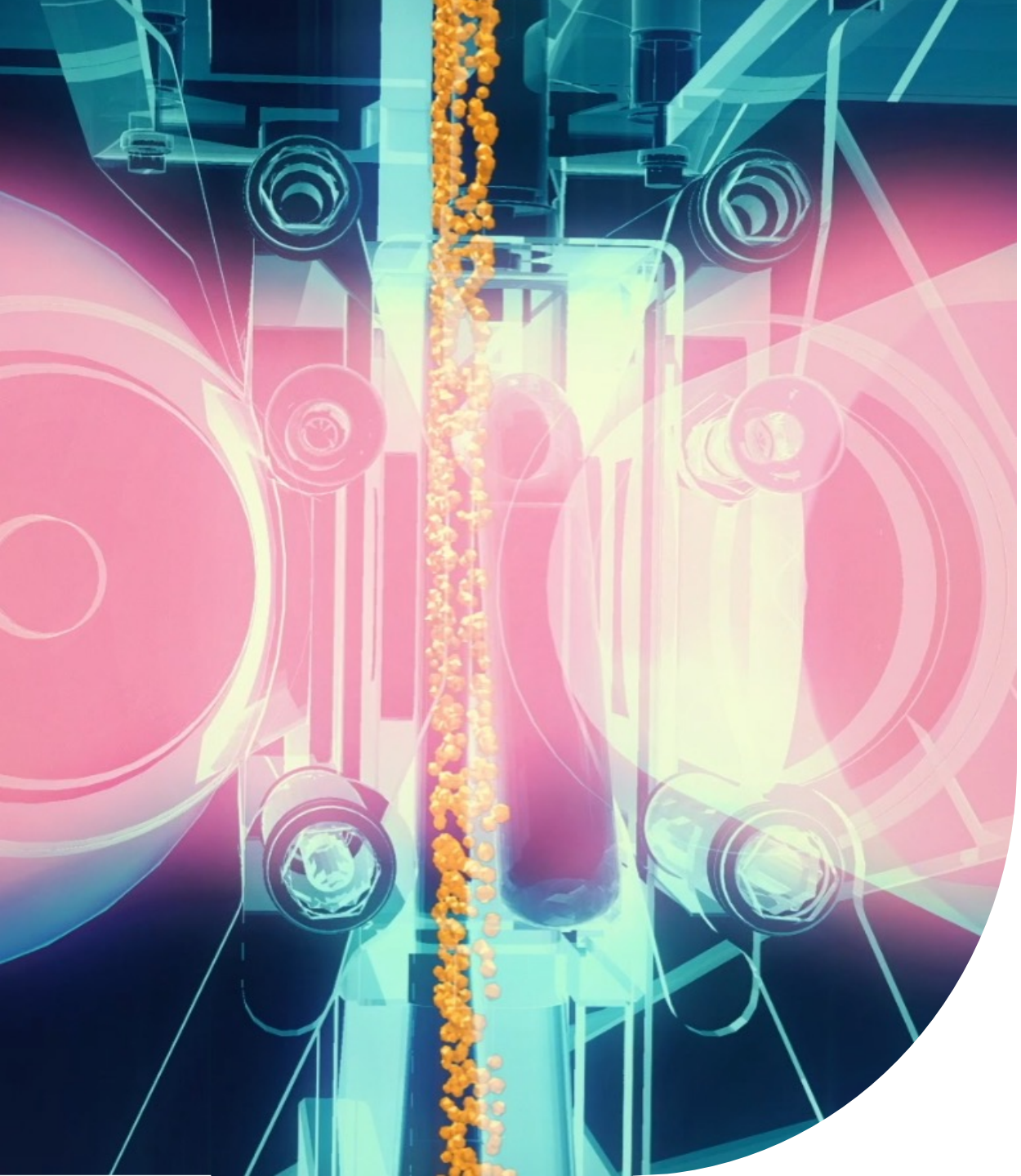


Matthew Murdoch
Buhler UK

Monte Carlo for low energy e-beam

Outline

- The challenges of Monte Carlo (MC)
- HEEB vs LEEB
- Some challenges of LEEB
- Example results

The balancing act

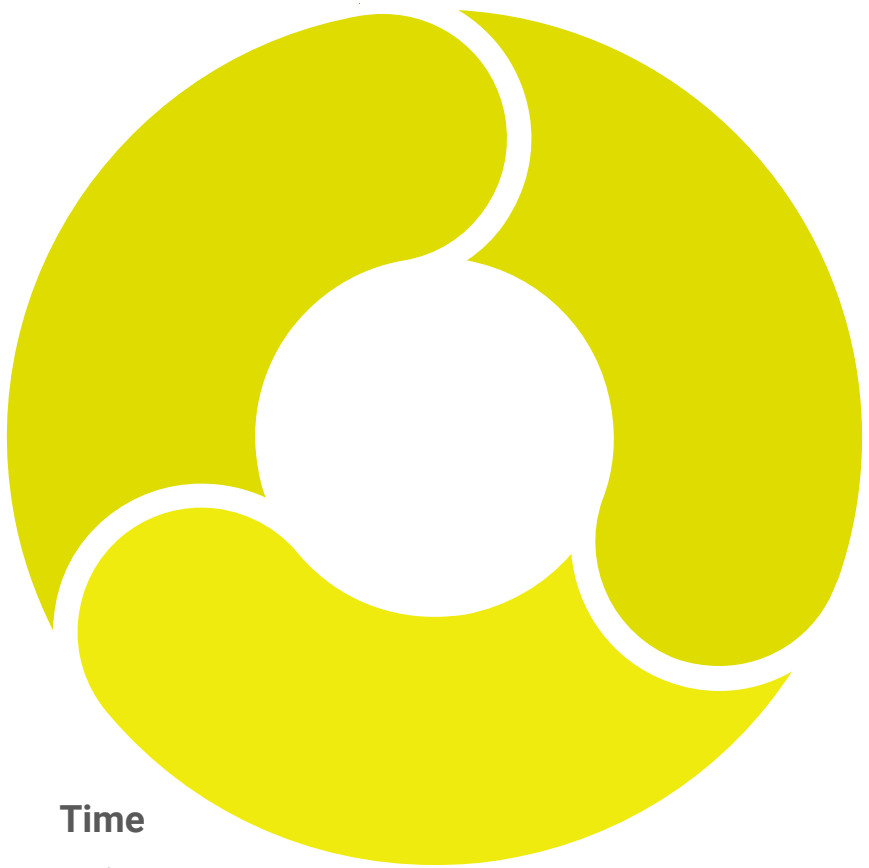
Hardware/Software

CPUs

RAM

Software capabilities

Cost



Simulation accuracy

Detail level

Uncertainties

Realism/validation

Time

Programming

Engineering

Processing

HEEB vs LEEB

Penetration depth

HE range ~ cm

LE range ~ 100s micron

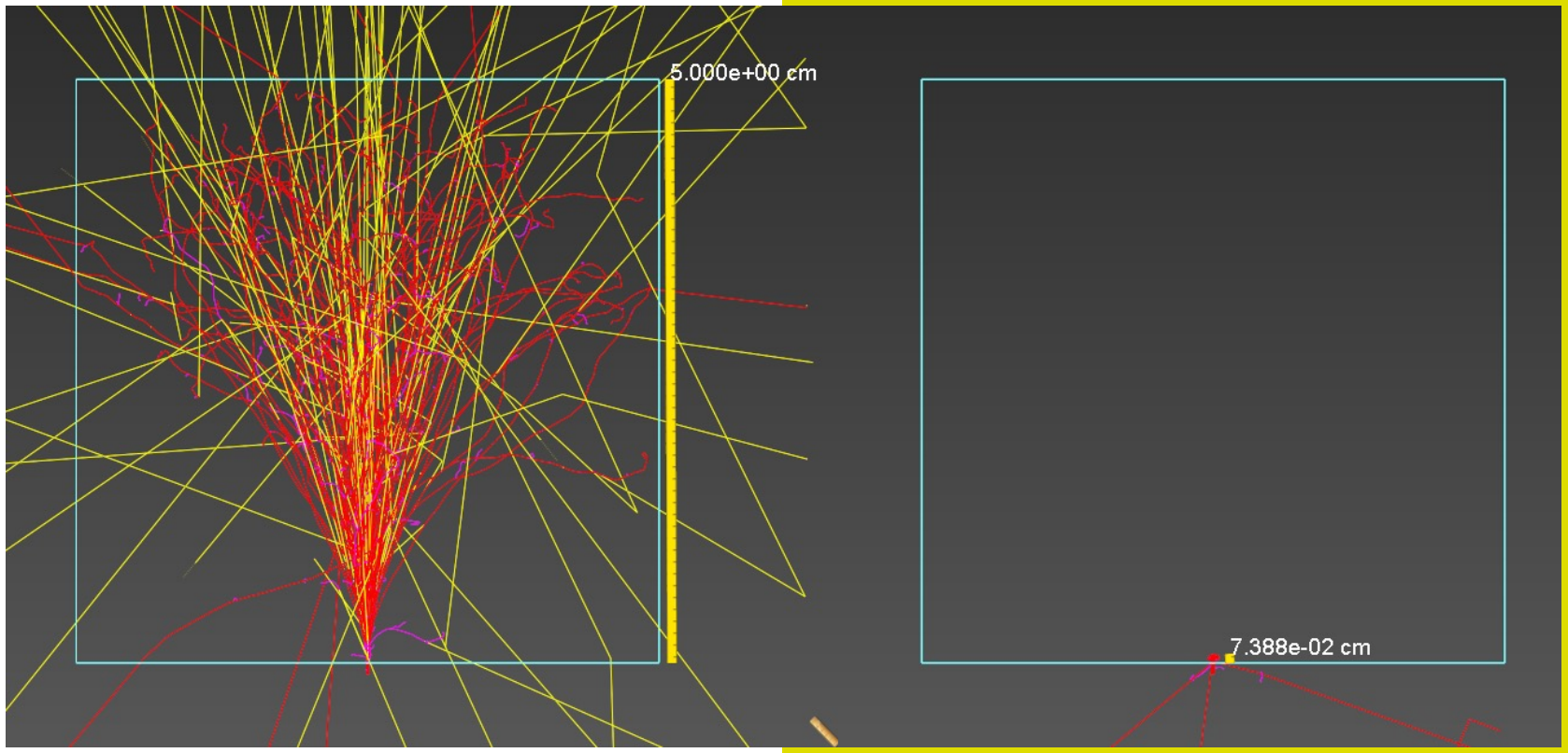
Length scale

Small scale matters

Details much more important

10 MeV electrons

300 keV electrons



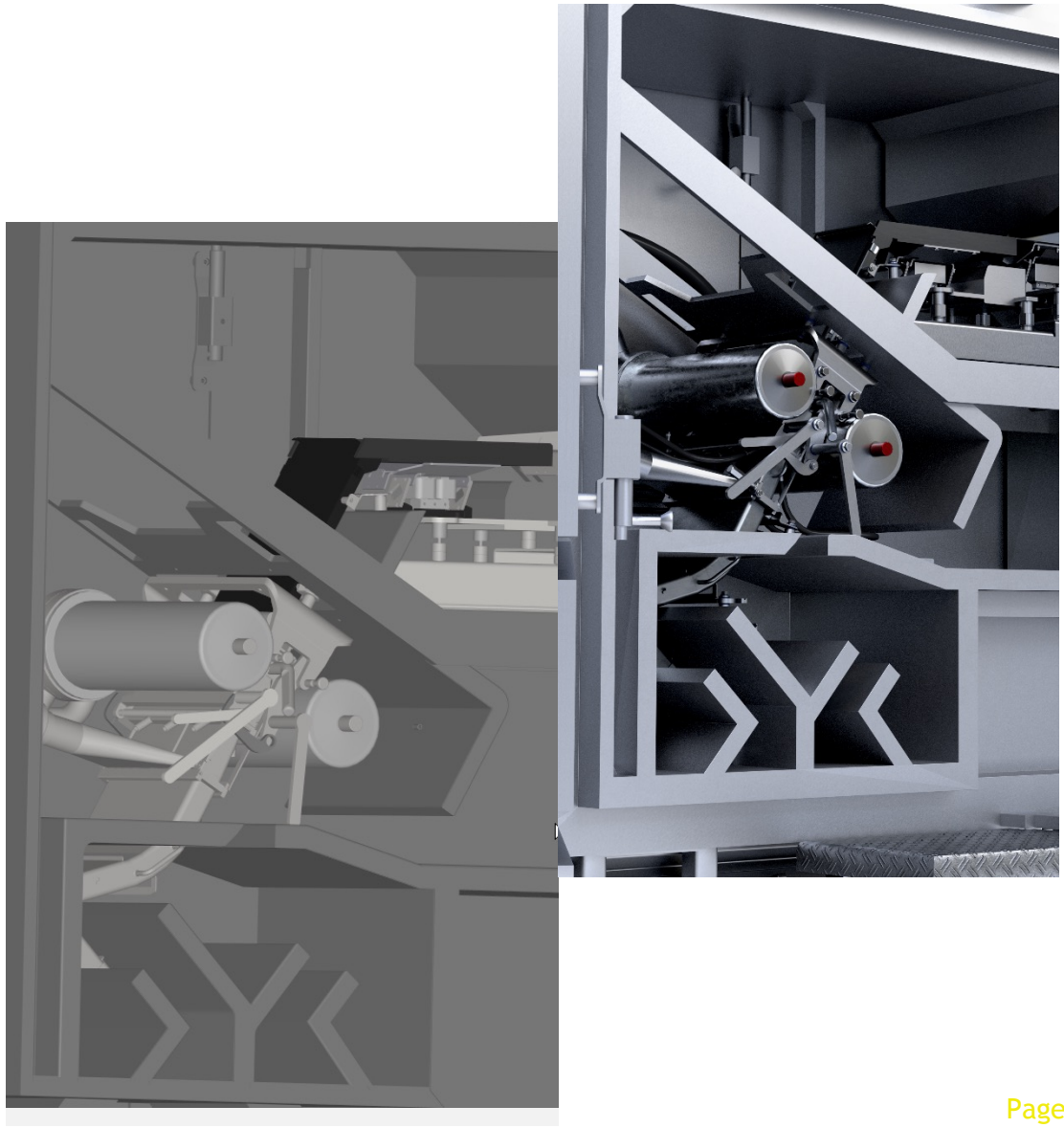
Processor Geometry

Core to simulations

High detail

Focus on treatment region

CAD is your friend



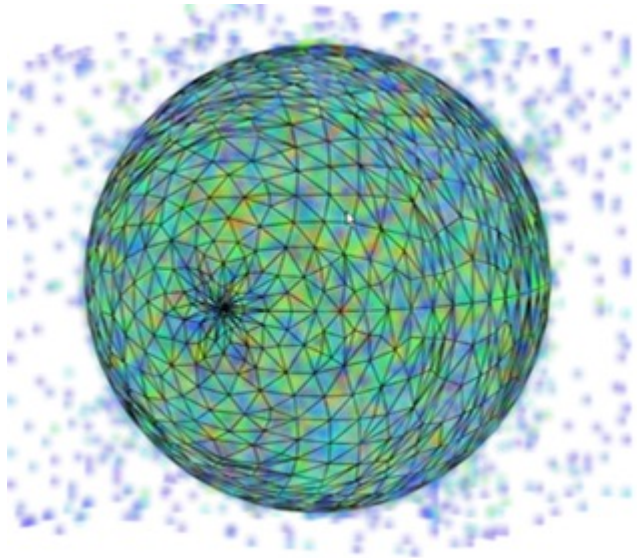
Food geometry

High variability

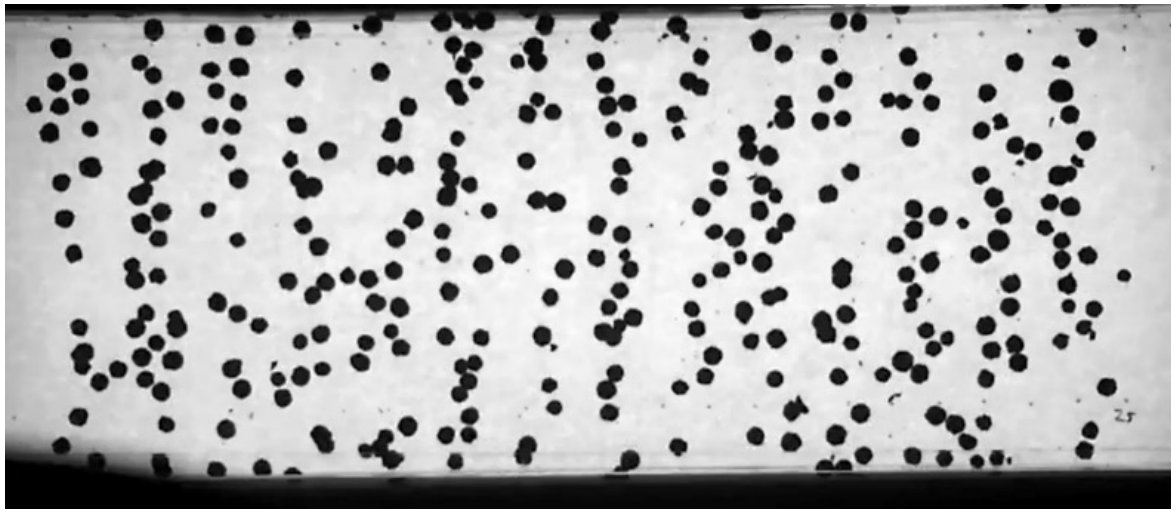
Lots of details

Product flow

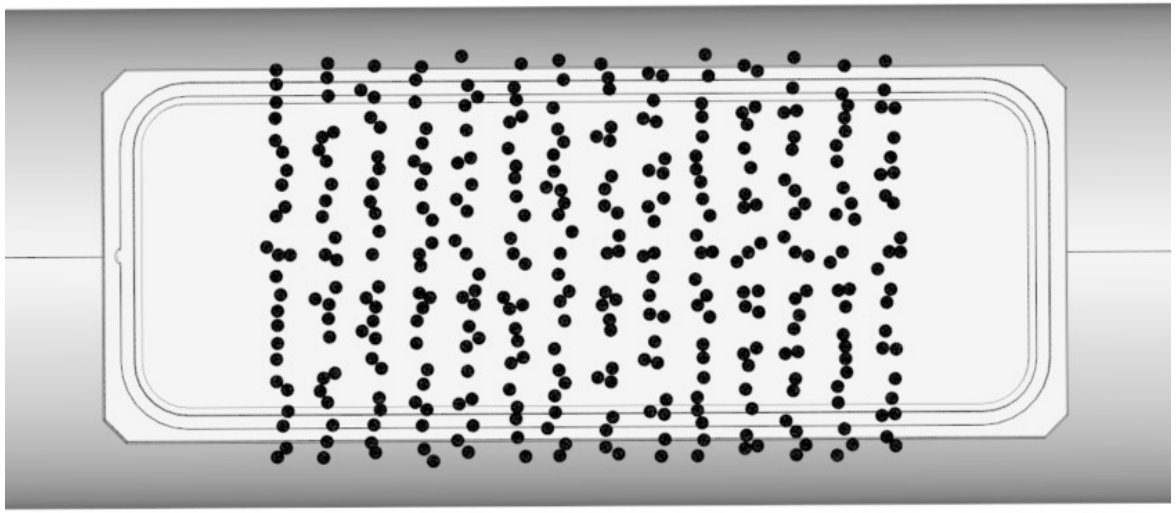
Peppercorn model



Photo



Simulation



Food simulation

Complex system

Speed

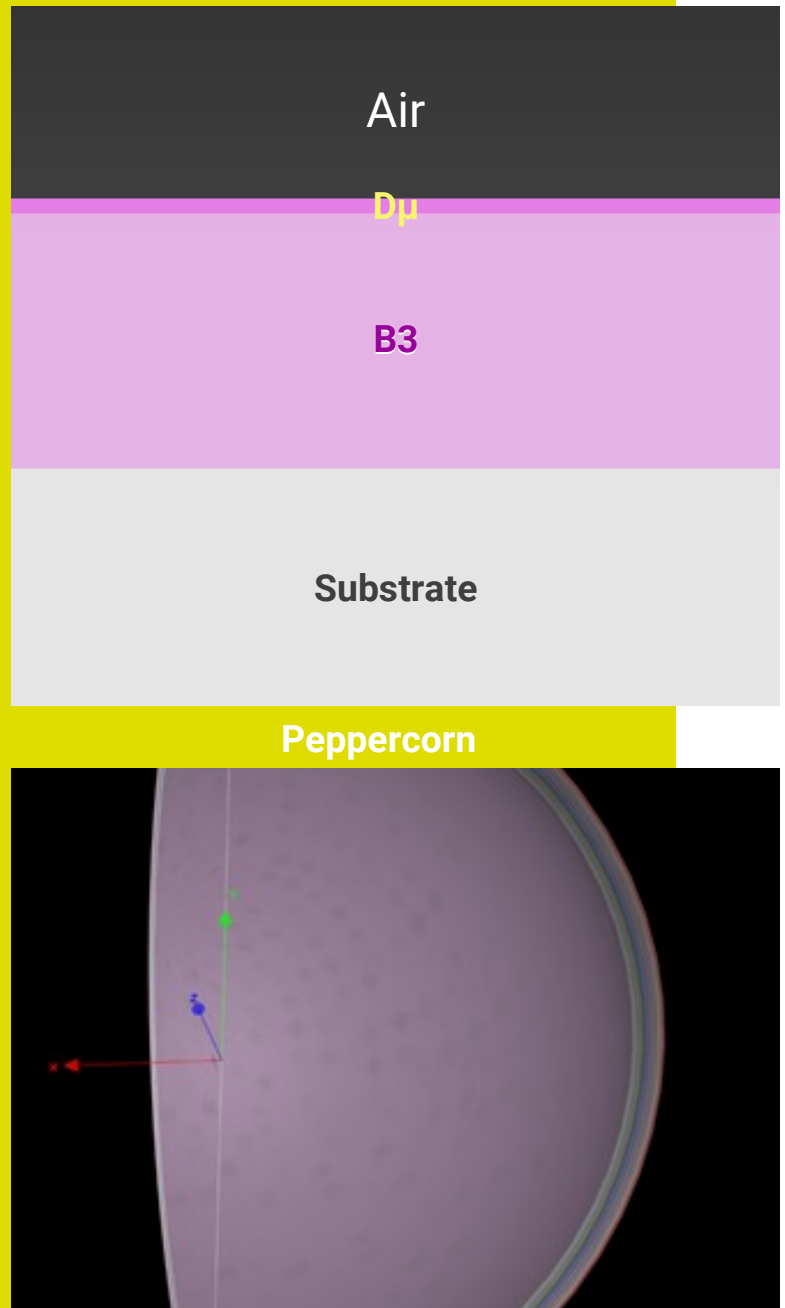
Rotation

'Shadowing'

Somewhat simplified for conveyed systems

Understand product flow

Recreate a 'typical' flow snapshot



Simulation & Dosimetry

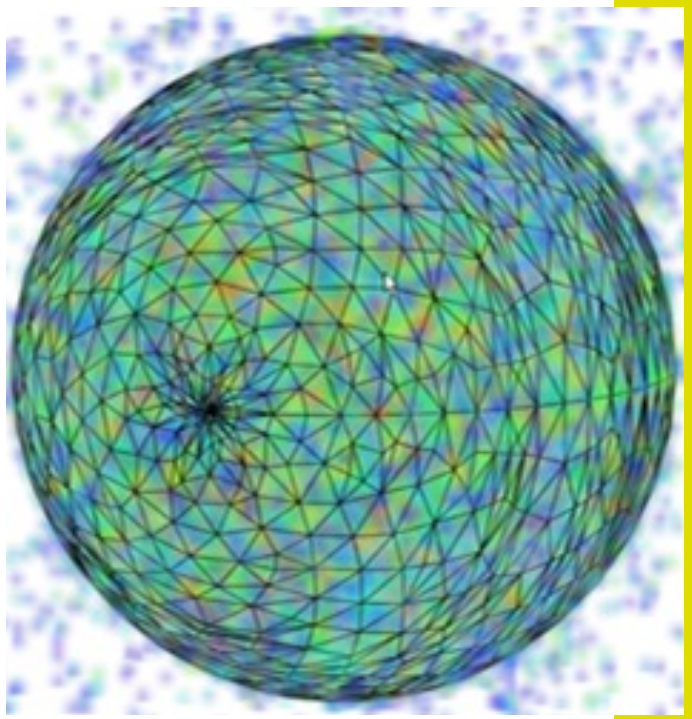
Link to dosimetry

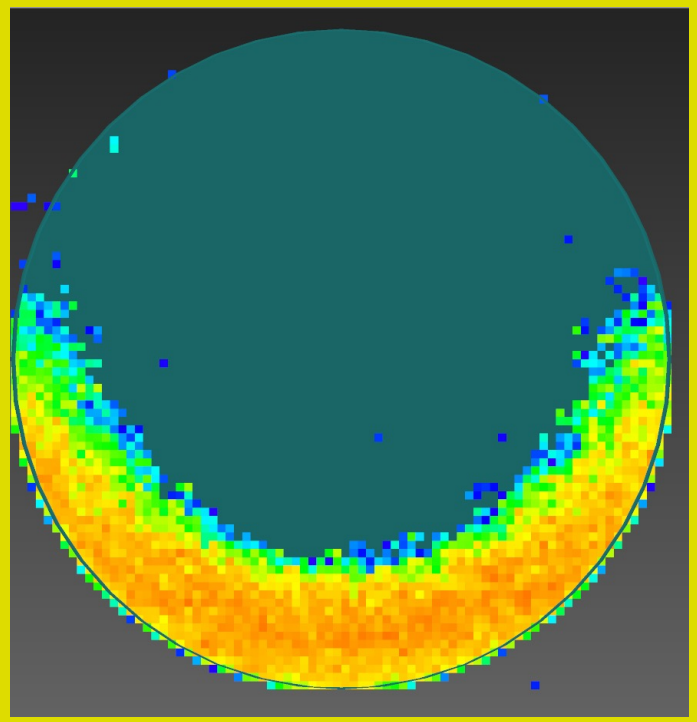
Generally measure Dμ – dose to first micron*

Create layers/shells

* “Dmu - A new concept in low-energy electron dosimetry“ - Helt-Hansen, et al

Scoring





Volumes

HEEB ~ mm^3

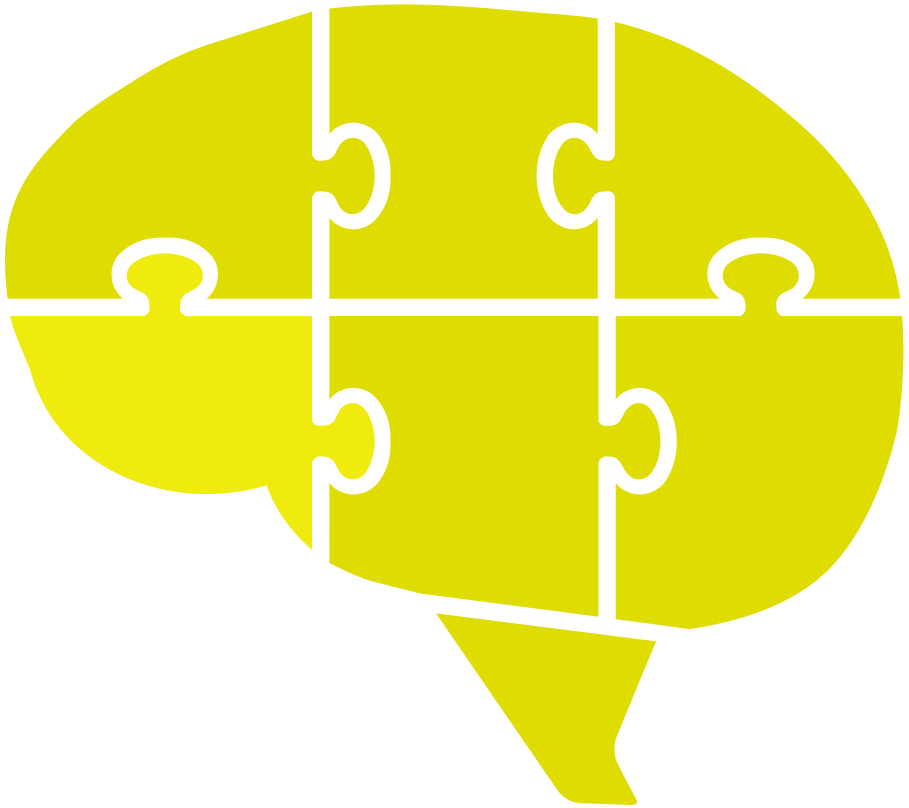
LEEB ~ μm^3

More memory, more CPU

Limited by software

-voxel shapes

Validation & tuning



1. Create
Idealised model

2. Test & Tune
Adjust to machine data

3. Validate
Compare to validation data

4. Predict
Simulate

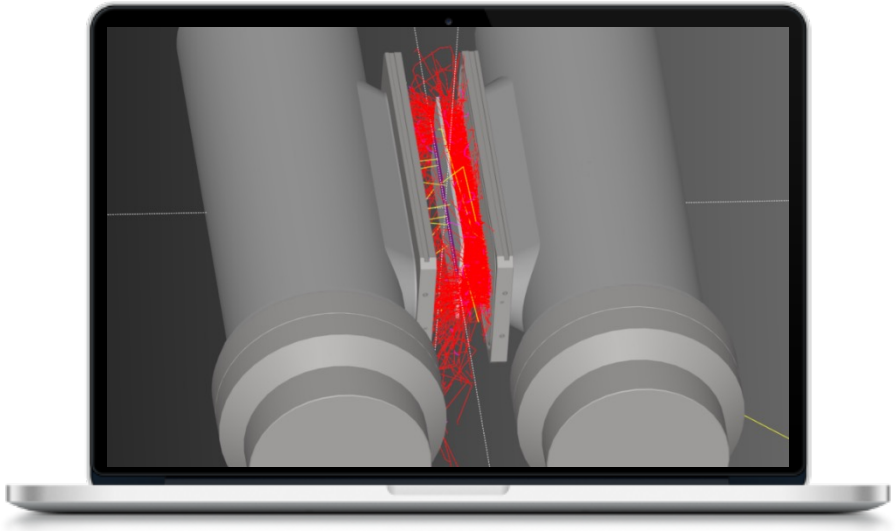
Operational Qualification

Describes beam

Quantifies & qualifies

Controlled parameters

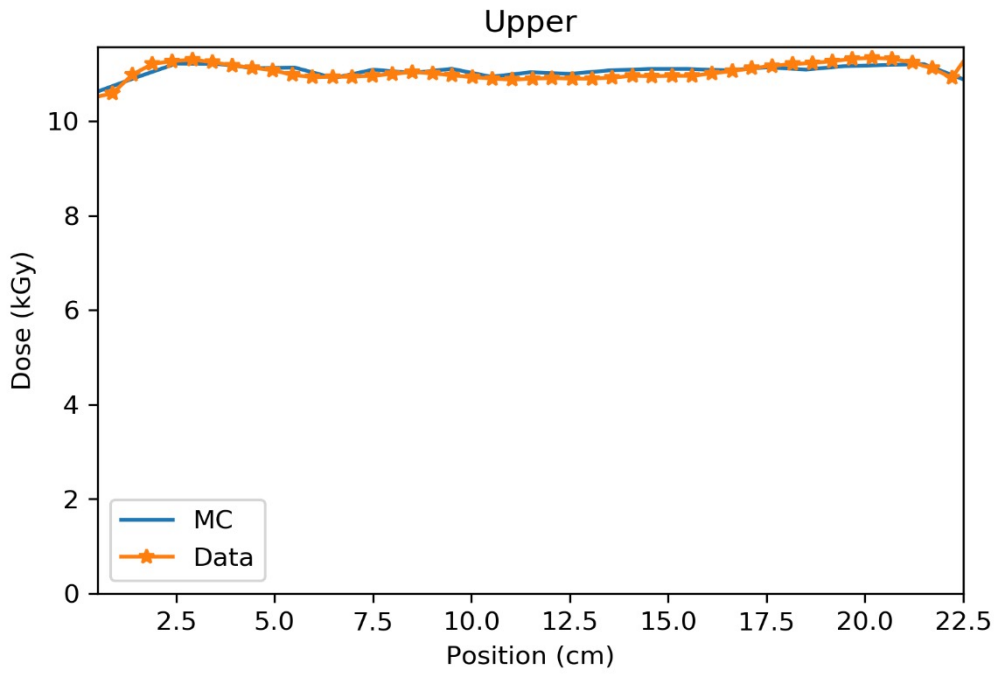
Easy to simulate & compare

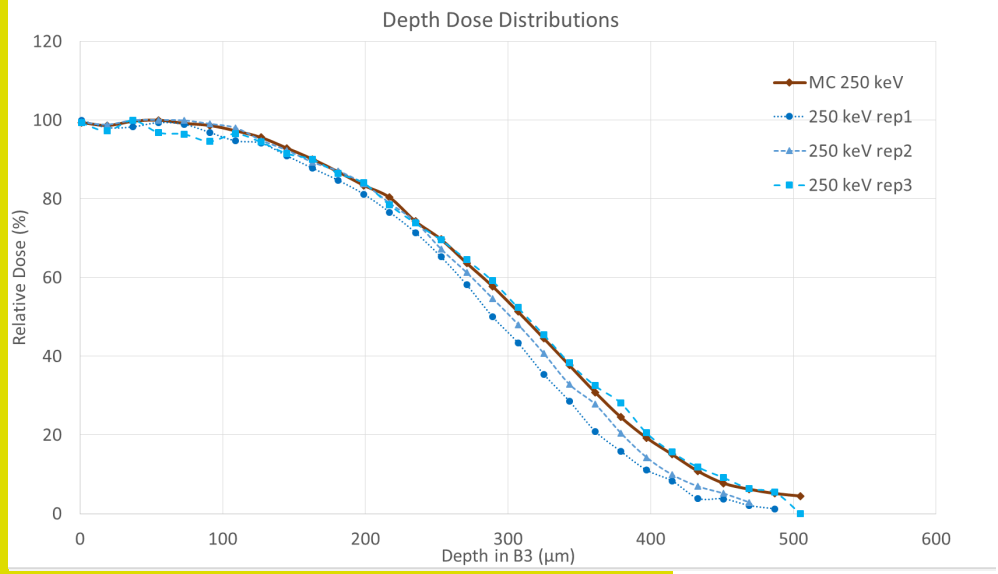


Simple geometries

Easy to simulate & compare data

Good candidate for tuning!





Tuning
Testing

Reproduce beam profile in simulation

High accuracy

Limited by dosimeter precision

Recreate depth dose profiles

More experimental uncertainty

Validation

OQ Voltage (keV)	MC - data residual (%)
250 (tuning)	0.4
225	-3.1
200	-2.5

PQ voltage (keV)	Data/MC residual (%)
250	-3.9
225	-2.6
200	-3.9

OQ, different voltages

Simple geometry, already set up

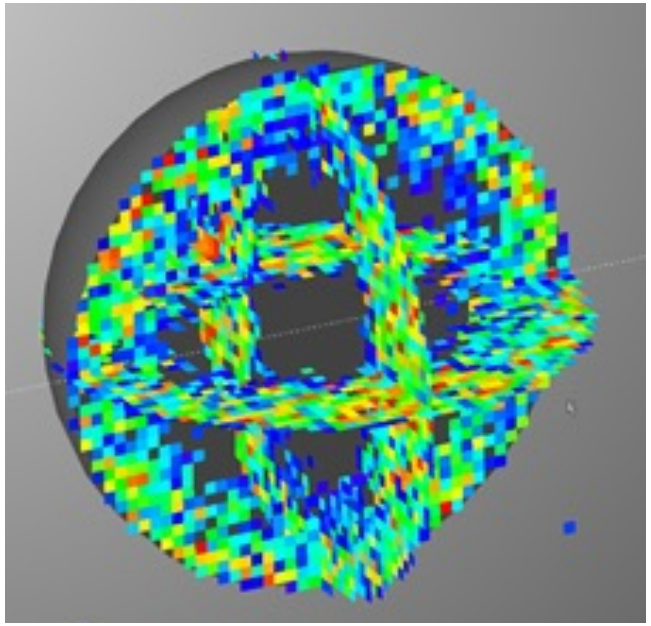
Expanded uncertainty

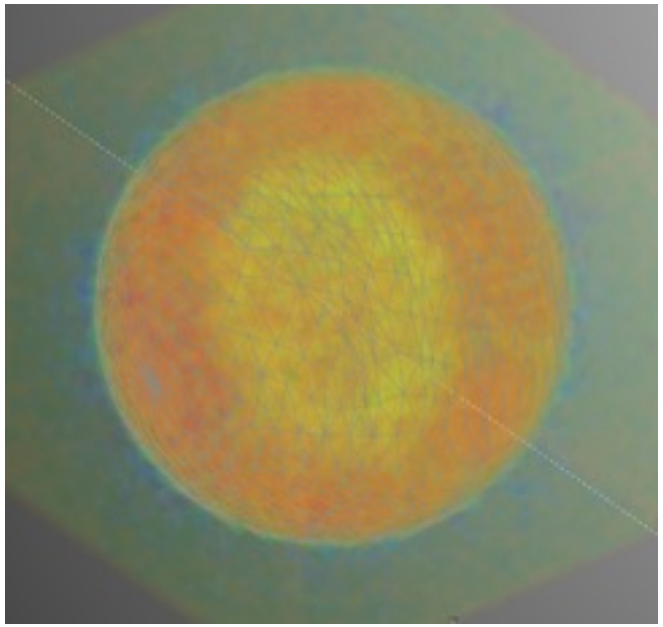
Performance qualification

Product simulation testing

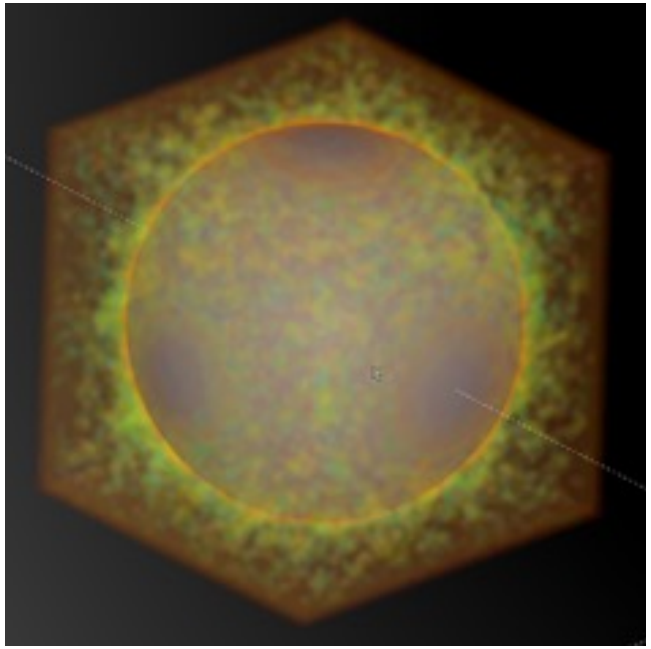
Another dataset

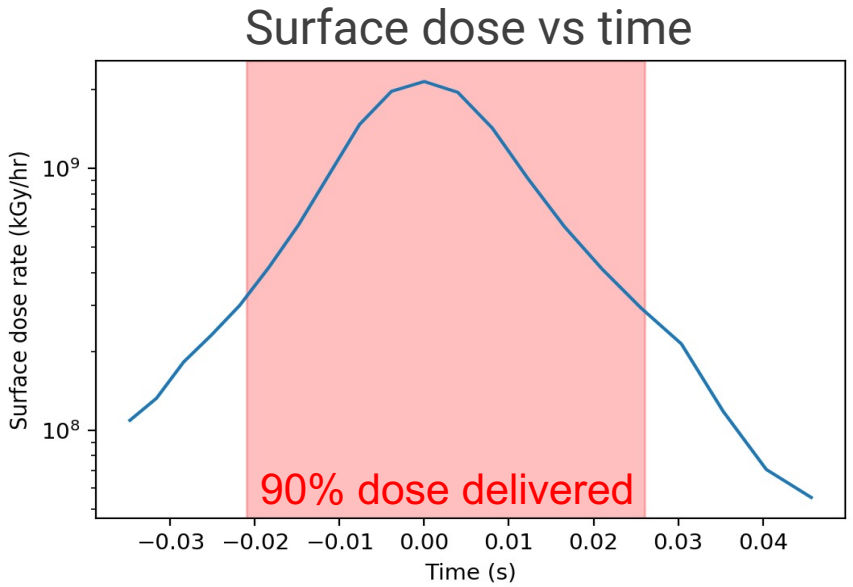
-Expanded uncertainties (process)

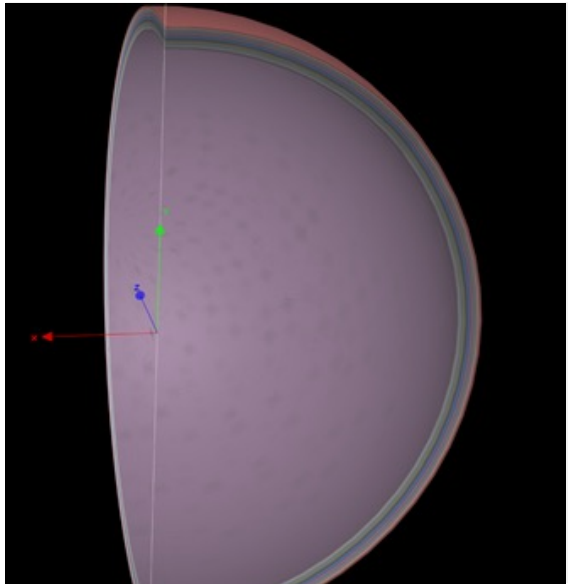


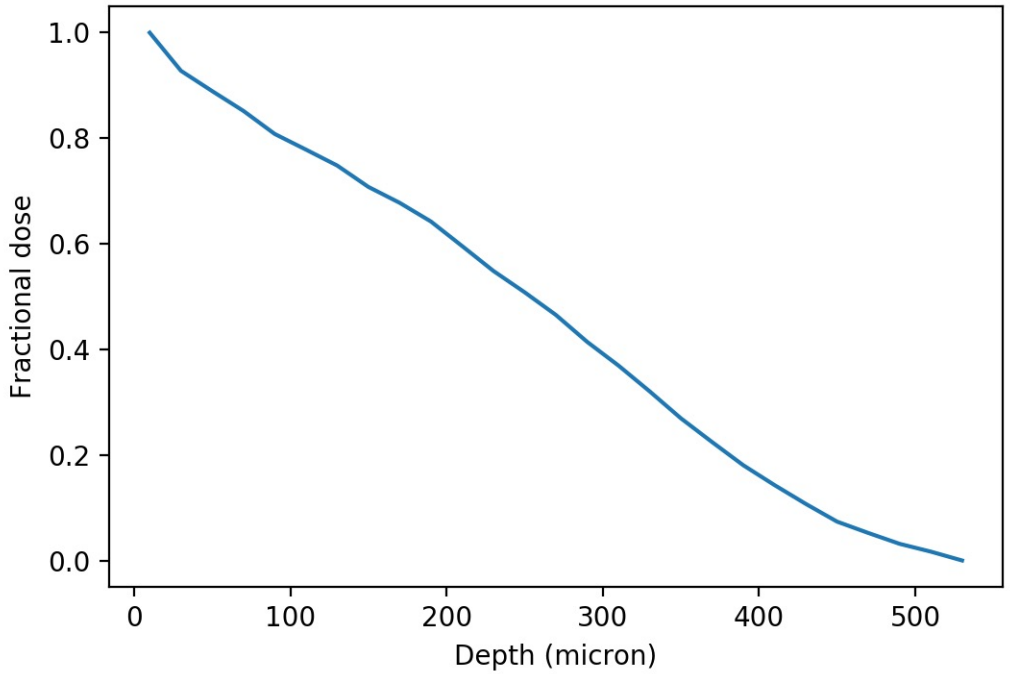


Peppercorn simulations









Depth dose simulation

Many layered product model

Estimate penetration depth

Idealized model

Qualitative understanding

Effect of 3D geometry

Summary

- LEEB has shorter range
- More detail needed
- Create, Tune, Validate, Predict, Understand

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Thanks.